INTERIM FINDINGS OF ACTS Ka-BAND PROPAGATION CAMPAIGN

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INTRODUCTION

The ACTS propagation campaign is focusing on two broad areas: 1) Rain/signal attenuation data collection at seven sites in North America, 2) Theoretical and empirical considerations for a global model to predict first & second order temporal and spatial statistics on attenuation, scintillation, coherence bandwidth, and depolarization due to weather (precipitation and atmospheric including interaction of weather with the antenna) for satellite systems at Ka-band. Through this effort, NASA is making a major contribution to growth of satellite communications services by providing timely data and models for performance prediction of Ka-Band satellite communications (satcom) systems.

The ACTS Satellite has two propagation beacons, one at 20.185 GHz with an EIRP of 22. dBW, the other at 27.5 GHz at an EIRP of 19 dBW. Specially designed ACTS Propagation Terminals have been installed at the following locations, selected to be representative of rain regions in North America:

Fairbanks, Alaska, ITU Rain Region C
Vancouver, British Columbia, ITU Rain Region B
Ft Collins, Colorado, ITU Rain Region E
Clarksburg, Maryland, ITU Rain Region K
Las Cruces, New Mexico, Rain Region M
Norman, Oklohama, Rain Region M
Tampa, Florida, Rain Region N.
Each site measures and records

The ACTS Propagation Terminal provides simultaneous beacon receiver and radiometer output data at the two beacon frequencies (20.185 and 27.5 GHz). Capacitive rain gauges were originally installed at all sites to provide instantaneous rain rate measurements; however they have proven unreliable and have been replaced by tipping bucket and/or optical rain gages, depending on the site. Rainfall is reported as one minute averaged rain rate. Data collection started in December 1993 at six of the seven sites, with the exception of the Clakrsburg where data collection began in March 1994. Current plans call for data collection through December of 1998 to provide 34 station years of comprehensive Ka-Band attenuation and rain-fall statistics for North America

INTERIM RESULTS

So far 20 station-years of ACTS Ka Band Propagation data have been analyzed and reported by the investigators at NASA Propagation Experimenters meetings and ACTS Propagation Studies Workshops [1], [2], [3] covering: Commutative Fade Distributions, scintillation, antenna diversity gain, and attenuation due to rain water on the antenna.

The dominant free-space propagation factor at Ka-band is attenuation caused by rain. Figure 1 shows the commutative 3 year rain fade distribution measured at the seven sites for the ACTS beacons at 20 and 27 GHz. [4]. It is interesting to note that , depending on the site, 2-5 dB (2- 7 dB) of link margin is required to allow for attenuation at 20 (27) GHz to assure link availability for 99% of the time. These link margin requirements are only slightly larger than margins commonly used for Ku band satcom systems.

Considerably higher link margins are needed to increase link availability to 99.9 o/o. As shown in table 1, depending on the site, 5 to 30 dB (7-50 dB) of link margin is required to allow for attenuation at 20 (27) GHz to assure link availability for 99.90/0 of the time. Link margins vary widely depending on weather conditions at each site and at some of the sites have very large values.

One should note that these results are based on experimental commutative fade distributions at the specific sites for a three year period spanning December 1994/November 1996. For system design, one should also allow for long term weather variations as well as dependence of weather on the exact location of the ground station. There are several models for predicting margin requirements for Ka-band link design. A detailed comparison of 13 station years of ACT-S Ka-band data has been made with the most popular models [5]. Depending on the model used, the RMS error between measurement and prediction models varied from 39.16 to 66.91 % (32.18 to 60.20%) at 22 (27 GHz) [5] . The COMSAT (USA) model provided the best match. Work has started to build models based on detailed local climate for better prediction of rain attenuation at Ka-band, [6]. Twenty seven station-years of ACTS data will be used to validate the new model. It is expected that this approach will provide a better prediction tool.

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REFERENCES

[1] Proceedings of the Twenty-First NASA Propagation Experimenters Meeting (NAPEX XXI], and the Advanced Communications Technology Satellite (ACTS) Propagation Studies Workshop, JPL Publication 97-13

[2] Presentations of the Ninth Advanced Communications Technology Satellite Propagation Studies Workshop, Herndon, VA, November 19-20, 1996, JPL Publication 93-3.

[3] Proceedings of the Twentieth NASA Propagation Experimenters Meeting (NAPEX XX), and the Advanced Communications Technology Satellite (ACTS) Propagation Studies Workshop, JPL Publication 96-20.

[4] X. Wang, D. Ramachadran, P. Robinson, R. K. Crane, "ACTS Propagation Studies in Oklahoma", Proceedings of the Twenty-First NASA Propagation Experimenters Meeting (NAPEX XXI], and the Advanced Communications Technology Satellite (ACTS) Propagation Studies Workshop, pp 1-157 to 1-192, JPL Publication 97-13.

[5] G. Feldhake, "A Comparison of 11 Rain Attenuation Models with 2 years of ACTS Data from seven Sites") Presentations of the Ninth Advanced Communications Technology Satellite Propagation Studies Workshop, Herndon, VA, November 19-20, 1996, JPL Publication 93-3.

[6] R.K. Crane, "A New Rain-Fade Distribution Model: Preliminary Version for Annual Statistics", Proceedings of the Twenty-First NASA Propagation Experimenters Meeting (NAPEX XXI], and the Advanced Communications Technology Satellite (ACTS) Propagation Studies Workshop, pp 2/5-/2/15, JPL Publication 97-13

Figure .b

Three-Years ACTS 27.5 GHz Beacon Free Space Attenuation

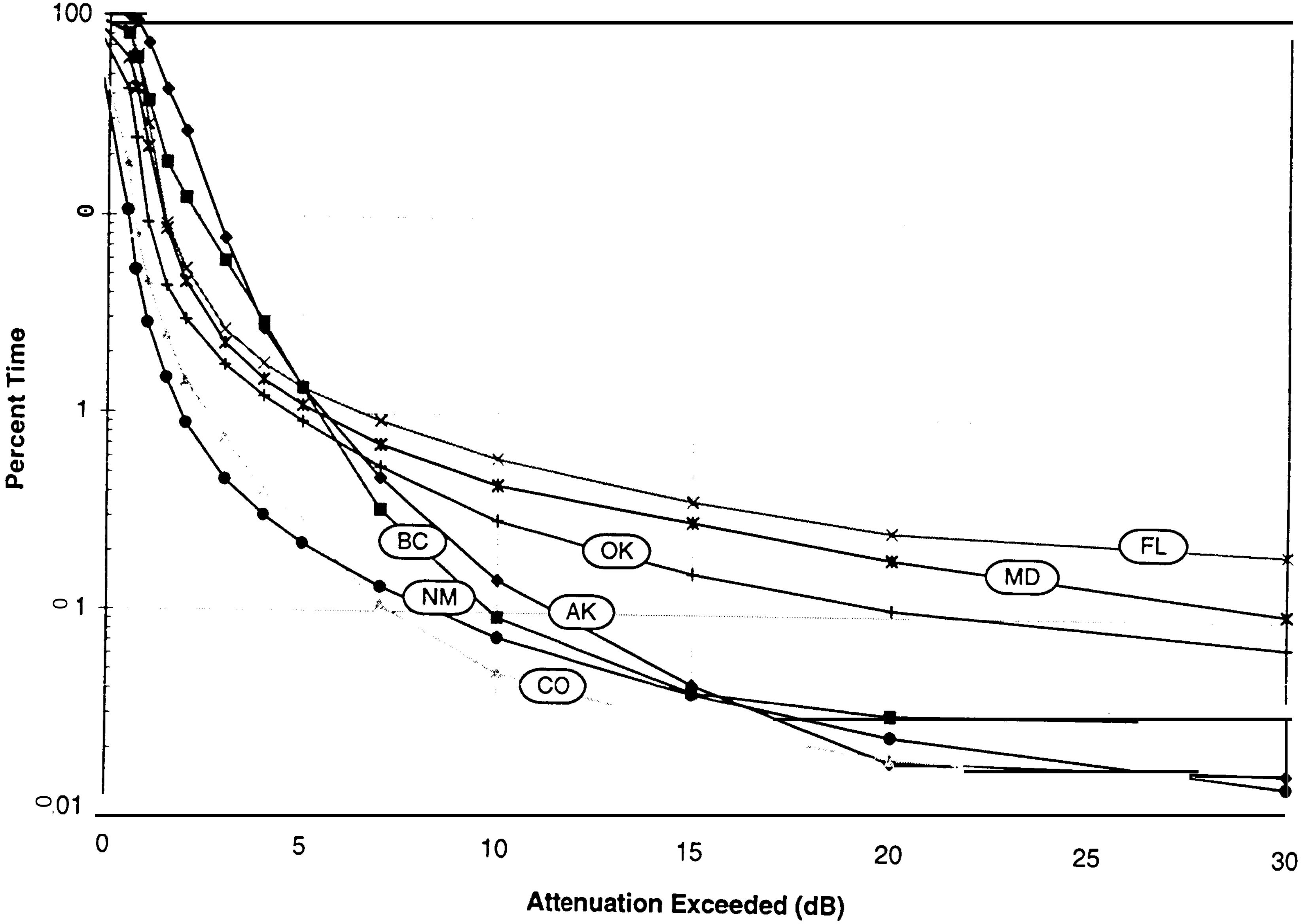

Figure 14a Three-Years ACTS 20.2 GHz Beacon Free Space Attenuation

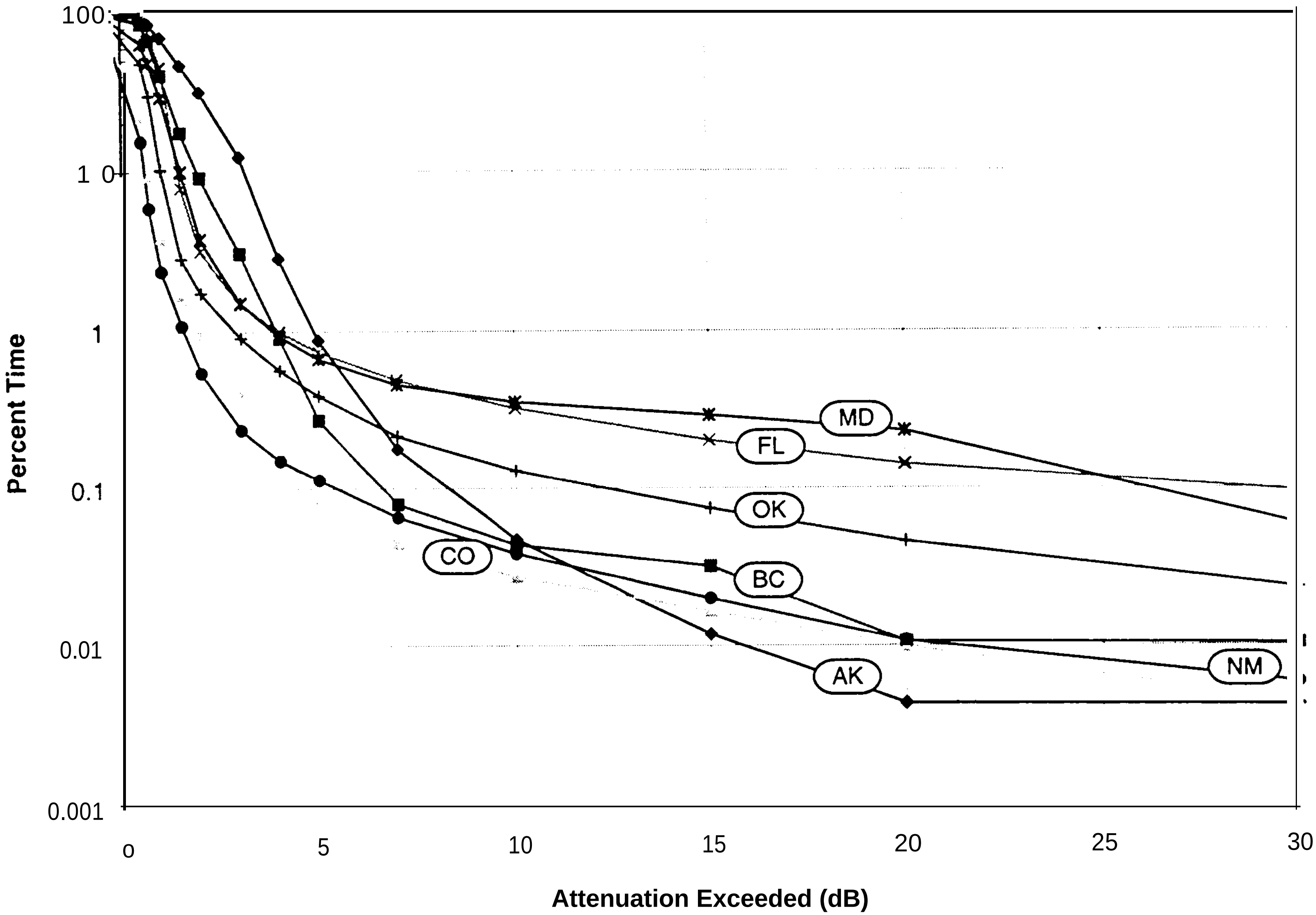

Table 1, Attenuation margin based on ACTS propagation measurements for the period December 94/November 96.

Location	Attenuation margin for 990/' link availability (1) 20,2 GHz	27.5 GHz	Attenuation Link margin for 99.90/0 link availability (1) 20.2 GHz	27.5 GHz
AK	5 dB	6 dB	8 dB	12 dB
BC	4 dB	6 dB	7 dB	10 dB
CO	3 dB	3 dB	5 dB	7 dB
FL	4 dB	7 dB	30 dB	50 dB (2)
MD	4 dB	5 dB	26 dB	30 dB
NM	2 dB	2 dB	5 dB	8 dB
OK	3 dB	5 dB	12 dB	22 dB

Notes:

(1) Additional margins should be added to allow for variations due to unpredictable nature of weather.

(2) By extrapolation